SECTION 4
STUDY PLAN

This section provides the conceptual study work plan for completion of the FKCCS. Data compiled for all elements shall be the result of a comprehensive, documented literature search. Consultation with others regarding any current research activity will be conducted to avoid duplication of effort in data collection. Appropriate references will be provided for all data and information. Data collection and database development will be coordinated with and include the requirements of the CCAM.

Natural Resources Category

The Natural Resources category addresses water quality, ecosystems and species of concern found within the Florida Keys. The work performed for this category will include identification of indicator species, keystone species and species of concern; natural resource indicators of sustainability; determination of scientifically derived requirements, responses, limiting factors and tolerance limits, where identifiable and quantifiable, for natural resources and species of concern; and development of the relationship(s) that describe the impact that land development activities and population growth have on the environment and human infrastructure in the Florida Keys.

Water Quality Element

Anthropogenic types and levels of water quality impacts vary throughout the Keys. The waters in and around the Florida Keys are predominantly designated as Outstanding Florida Waters. This designation prohibits any degradation of water quality, however there are no set water quality standards. Water quality parameters that will sustain a healthy marine environment can be defined by certain requirements, responses, limiting factors and tolerance limits. Also, some water quality parameters, such as those affected by effluent, may be altered by technology (e.g. stormwater and sewage treatment). Two master plans are currently under development by Monroe County to address water quality issues: the Monroe County Sanitary Wastewater Master Plan and the Monroe County Stormwater Master Plan. All applicable information from these master plans and the Florida Keys National Marine Sanctuary Water Quality Protection Program (WQPP) will be incorporated into the water quality analysis to avoid duplication of effort.

Task 1. Literature Review. All available literature, information, data and research, and published science literature regarding ground and surface water quality, nearshore flushing, and hydrogeology will be reviewed, compiled, and evaluated. Additional archival research and interviews will be conducted if required. All applicable information from the Florida Keys National Marine Sanctuary WQPP will be incorporated into this literature review. Information to be acquired shall include, but is not limited to, the following:

Task 1. a. Property History and Usage. Readily available data only will be accessed to incorporate property history and usage into the knowledge database for this study. Usage of property by the Federal Government, industrial and commercial businesses will be highlighted. Information on property history and usage will include (1) uses of current and former owners, (2) type and quantity of structural demolition debris and/or residue, and (3) information that may indicate the presence of hazardous or toxic substances. This shall involve inventory of potentially hazardous substances used on the property (e.g. fuels, solvents, chemicals), storage practices (e.g. underground storage tanks, tanks and drums) and disposal practices (e.g. landfills, dumps, and septic systems). The potential presence of underground storage tanks on the property will be determined and the following information for each probable tank will be provided: location, size, probable contents and quantity, age, depth, present use and condition.

Task 1.b. Hazardous, Toxic and Radioactive Waste (HTRW) Coordination Documentation. The location of HTRW contamination sites within the Florida Keys will be incorporated into the knowledge database for this study and will also be a factor for consideration during water quality assessments. GIS mapping of HTRW sites will be included.

Readily available data and databases of federal, state, regional and local agencies will be accessed to determine the location of any HTRW contamination sites in the study area. Available federal databases to include are the National Priorities List, Comprehensive Environmental Response, Compensation, and Liability Information System list, Resource Conservation and Recovery Act (RCRA) Transportation, Storage and Disposal (TSD) facilities List, RCRA generators list, Toxic Release Inventory and the Emergency Response Notification System (ERNS) list (hazardous spills). State databases to include are FDEP's HTRW site list, landfill and/or solid waste disposal site list, and leaking Underground Storage Tank (UST) list. The federal RCRA and ERNS lists and the state landfill and/or solid waste disposal site list and the leaking UST list provide the location of potential HTRW sites. Information on potential HTRW sites could be useful in the water quality assessments and, in the future, if water quality begins to decline in the vicinity of one of these sites.

The following information for each HTRW contamination site will be provided, if available:

(1) Identification of the nature and extent of contamination including chemical constituents,

(2) Qualitative analysis of the impacts of the contamination in the absence of corrective action, including (a) identification of potential source origins, (b) contaminant release mechanisms, (c) exposure routes and (d) potential exposure risk and adverse health effects to human and wildlife populations,

(3) Surface and sub-surface conditions,

(4) Vegetation (i.e. any studies conducted for the purpose of revealing distressed vegetation or illegal disposal sites within hydrologically-influenced zones),

(5) Soils (i.e. soil surveys consisting of textured olfactory analysis and using official geological designations),

(6) Above ground and underground storage tanks,

(7) Confined waters (e.g. canal systems), and

(8) Wells of any type (water or monitoring, etc.).

Task 1.c. Monroe County Sanitary Wastewater Master Plan (SWMP). All available and applicable information from the Wastewater Master Plan will be incorporated into this water quality analysis including, at a minimum:

(1) Pollutant loading estimates from existing on-site disposal systems (OSDS), cesspits, package treatment plants, and modeling results of other point and non-point sources on the Florida Keys.

(2) Pollutant loading estimates from new or improved wastewater treatment systems meeting updated operational standards,

(3) Inventories of wastewater treatment plants and OSDS areas which identify (a) agency responsible for operations, (b) plant capacities, (c) number and type of hook-ups, (d) costs associated with improving facilities to meet minimum level of service standards, (e) funding sources and construction schedules for system improvements, and (f) average and peak flow design capacity for sanitary sewer facilities.

Task 1.d. Monroe County Stormwater Master Plan (SMP). All available and applicable information from the SMP will be incorporated into this water quality analysis including, at a minimum:

(1) Level of retention and/or detention in the overall system,

(2) Projection of new development and redevelopment projects for input into scenario assumptions,

(3) An inventory of stormwater conveyance, treatment and discharge systems, both natural and constructed,

(4) The capacity, treatment efficiency, and estimated pollutant loading of each stormwater conveyance, treatment and discharge system, and

(5) The effects on water quality of pollutant loading, including the effects on any freshwater storage areas.

Task 2. Selection of Case Study Areas. These case study areas will be chosen for completion of a nutrient/contaminant loading analysis to nearshore waters. The case study areas will coincide with those utilized in the SWMP and the SMP, considering wastewater and stormwater "hot spots" to be identified in tasks 3 and 4 of this element and the impacts of development typical for sections of the Florida Keys, given the varying hydrologic and geologic conditions along the upper, middle and lower Keys. For example, a more developed area such as Key West would represent a highly developed service area, whereas some undeveloped middle Key would represent the least developed area of the island chain.

Task 3. Wastewater Evaluation. Wastewater effluent from on-site disposal systems (OSDS), including septic tanks and cesspits, may be degrading water quality in the Florida Keys, especially in confined water bodies (e.g. canals). There is also concern on the effects of wastewater effluent in the nearshore waters (EPA 1992). Also, discharges from sewage treatment/package plants add nutrients into injection wells and nearshore receiving waters. This evaluation addresses quality and quantity of wastewater flows and wastewater impacts on water quality. These tasks are to be accomplished in coordination with the development of the Monroe County SWMP, which is currently underway. Within this study, wastewater is also treated as a separable element under the Human Infrastructure Category, since the required infrastructure, and associated cost, for wastewater treatment in the Florida Keys for the future scenarios will be determined by the anticipated patterns of land development activities.

Task 3.a. Identify "Hot Spots". Water quality "hot spots" for confined, groundwater and nearshore waters will be identified using water quality data and wastewater loading estimates from Monroe County, FKNMS and other sources. At a minimum, the following will be considered in the "hot spot" identification:

(1) Known potable water flows; the proportion of cesspools, septic tanks (permitted On-site Wastewater Treatment Systems), Alternative Treatment Units, and package Wastewater Treatment Plants; and the number of lots smaller than 0.25 acre;

(2) Documented evidence of water quality problems;

(3) Developed canals with poor circulation or water exchange characteristics;

(4) Development and wastewater loading density; and

(5) The percent of build-out presently attained (i.e. the potential for future development and increased adverse water quality impacts).

The "hot spot" identification list will include "hot spots" already identified in the Phase I and II reports of the FKNMS Water Quality Protection Program as well as any modifications proposed by the South Florida Water Management District and/or other appropriate agencies. The "hot spot" list will include areas where live-aboards and recreational vessels discharge significant quantities of pollutants. The analysis will account for all known pollution discharge types from vessels (i.e. sanitary wastes, hydrocarbons, bilge, etc.). Areas where Total Nitrogen and Total Phosphorus from vessel discharge make up a significant portion (> 3% TN, > 5% TP) of every wastewater discharge shall be specially noted as areas of appreciable vessel nutrient loading. The resultant "hot spot" list will be utilized in the water quality modeling described later in this element.

Task 3.b. Develop Relationship Between Wastewater Effect on Water Quality and Land Development Activities/Effective Population Change. This relationship will predict changes in water quality due to wastewater and effective population change, providing a link between land development activities/effective human population and water quality in the Florida Keys. This relationship will be used by the CCAM to simulate future scenarios. This relationship will be developed through a series of facilitated workshops held immediately after study initiation. See Section 3, Study Elements, Task 5.

Task 4. Stormwater Evaluation. Stormwater runoff may be a key factor in the degradation of water quality in confined and nearshore waters. Stormwater inputs are typically known to cause increased nutrient levels, reduced water transparency, sedimentation, contamination from spilled oil and petroleum products, pesticides, herbicides, trace elements, and heavy metals. These impacts may be affecting the marine communities in the Florida Keys. This evaluation will address stormwater quality and identify areas of significant impact. Within this study, stormwater is also treated as a separable element under the Human Infrastructure Category, since the required infrastructure, and associated cost, for stormwater treatment in the Florida Keys for the future scenarios will be determined by the anticipated patterns of land development activities.

Task 4.a. Determine Stormwater Impacts. The Water Quality Protection Program (WQPP) Phase II Report and the WQPP Document for the Florida Keys National Marine Sanctuary, July 1996 will be consulted for evaluation of currently established "hot spots." Currently, no "hot spots" specifically attributable to stormwater runoff have been identified.

Task 4.b. Identify Chemical Constituents of Stormwater Run-Off. Scientifically derived estimates will be made of the amounts of suspended solids, hydrocarbons, pesticides, herbicides, heavy metals and other toxic substances that enter nearshore waters via stormwater runoff.

Task 4.c. Develop Relationship Between Stormwater Runoff Effect on Water Quality and Land Development Activities/Effective Population Change. This

relationship will predict changes in water quality due to stormwater and effective population change, providing a link between land development activities/effective human population and water quality in the Florida Keys. This relationship will be used by the CCAM to simulate future scenarios. This relationship will be developed through a series of facilitated workshops held immediately after study initiation. See Section 3, Study Elements, Task 5.

Task 5. Water Quality Modeling. Information regarding the effects on water quality from stormwater runoff and pollutant loading will require water quality modeling. This analysis is intended to generate scientifically derived data to be incorporated into the CCAM for assessing the impacts of human infrastructure on water quality in the Florida Keys and to define the water quality carrying capacity of each case study area by projecting the anticipated level of nutrient/pollutant loading that is possible without degrading water quality in the Florida Keys. The model will describe the site specific interactions between local geology, surface water, nearshore water, existing site specific land uses, nutrient loading sources and quantities, pollutant loading sources and quantities, surface runoff, shoreline erosion, and live-aboard vessels. The work described under this task will be conducted for each case study area.

Task 5.a. Mapping of Contributing Areas. Surface runoff and groundwater input into nearshore coastal waters for each case study area will be identified based upon available topographic maps. When pre-existing hydrogeological data is not available, a site investigation will be necessary to determine groundwater flow conditions for each case study area. Groundwater flow characteristics are to be determined from information derived from the installation of three to six monitoring wells in each case study area.

Task 5.b. Water Quality Sampling and Analysis. The existing water quality databases from academia, U.S. Geological Survey (USGS), Florida International University, University of Miami, National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), South Florida Water Management District (SFWMD) and Monroe County will be supplemented, where necessary. This may include the collection of both ground and surface water samples. Sampling will be conducted in accordance with Florida Department of Environmental Protection (FDEP) requirements.

Task 5.c. Nearshore Transport Analysis. Water circulation is a critical component in moving nutrients and sediment from points of origin to their ultimate destination. Important time frames are days (storm and hurricane impacts), months (seasonal impacts) and years (cumulative impacts). An analysis of flushing characteristics and circulation patterns of the nearshore waters of each case study area will be conducted (i.e. pattern of release and nearshore transport of nutrients/pollutants from established groundwater routes and/or point and non-point sources). The Florida Bay hydrodynamic modeling (USACE, Waterways Experiment Station) and existing nautical charts and topographic maps will provide some of the available data regarding flow and bathymetry.

Model Oversight Committee and Workshop. There are a couple of options available for the modeling of nearshore water circulation in the Florida Keys, which are discussed in the following paragraphs. A model oversight committee will be established to direct this study element. The Committee will consist of experts within the field of hydrodynamic and physical processes numerical modeling. A workshop with the committee will be held within the first few months after the study initiation. The workshop will determine the necessity, feasibility and scope of the numerical modeling effort, and the selection of model(s) to be used.

The Florida Bay Water Quality Study includes numerical modeling of water circulation (WC) and water quality (WQ). The Florida Keys are treated in the model as the boundary conditions. The numerical model grid terminates at about Big Pine Key, therefore, the lower Keys are not included. The grid could be extended and calibrated to include the lower Keys.

The other water circulation numerical modeling option is the ADvanced CIRCulation model for shelves, coasts, and estuaries (ADCIRC). ADCIRC simulates long wave hydrodynamic processes in a study area. ADCIRC employs a two-dimensional, depth-integrated finite element solution of the generalized wave-continuity equation. Recently, STWAVE has been coupled to run simultaneously with ADCIRC. STWAVE is a computationally efficient finite element numerical model for near-coast time independent spectral wave energy propagation simulations, which allows wave contributions to total water level and water circulation to be determined.

Considerable WC and WQ data is being collected as part of the comprehensive water quality monitoring program for the FKNMS. This data will be coupled with the selected water circulation model, and will serve as a probabilistic diagnostic tool for estimating the destination of land (i.e. wastewater, stormwater) and marine (i.e. boats) nutrient/pollutant loads.

Task 5.d. Land Use/Nutrient Loading Analysis. Land use and sewage treatment system mapping will be utilized to estimate the level of nutrient loading generated from existing and future development in each case study area. The resulting nutrient concentration in the groundwater will be estimated. After obtaining the estimated level of nutrient loading to groundwater and the flushing characteristics of the nearshore waters, an initial approximation of nutrient loading to nearshore receiving waters will be estimated for each case study area based on engineering judgment and hydrological expertise.

Task 5.e. Live-Aboards and Recreational Vessel Discharges. Analysis must account for all known pollution discharge types from vessels (e.g. sanitary wastes, hydrocarbons, bilge). These loading quantities shall be included in the overall nutrient loading estimate.

Task 5.f. Model Calibration. The developed model will be calibrated using existing water quality conditions measured in the nearshore waters. The calibration shall be

conducted by adjusting the loading parameters to obtain a best fit between the loading predicted by the model and actual conditions.

Task 5.g. Model Runs/Future Alternatives. The calibrated model will be applied to the future scenarios. Within the CCAM, the predicted concentrations will be compared with critical concentrations of nutrients expected to lead to degradation of water quality (i.e. water quality parameter requirements, responses, limited factors, and tolerance limits, if identified and quantified).

Task 5.h. Report. A Water Quality Analysis Report with will be prepared that documents the model preparation, assumptions, calibration and results. In addition, the nutrient loading numerical model would be submitted as part of the CCAM.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, research, and published scientific literature regarding ground and surface water quality, nearshore flushing and hydrogeology, not just the references and sources listed here.

Big Pine Key National Deer Refuge. Unpublished sampling water quality data for the north end of Big Pine Key.

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Pitts, P. A. 1994. An Investigation of Near-Bottom Flow Patterns Along and Across Hawk Channel, Florida Keys. Bulletin of Marine Science, 54(3): 610-620.

Pitts, P. A. and N. P. Smith. 1996. Final Report Long-term Transport Patterns in Florida Bay, Agreement MR020. Harbor Branch Oceanographic Institution.

Pitts, P. A. and N. P. Smith. 1996. Long-term Net Transport Through Three Tidal Channels in the Interior of Florida Bay, Final Report. Harbor Branch Oceanographic Institution. The Third Report in Connection with Cooperative Agreement CA 5280-4-9022.

Smith, N. P. 1994. Long-term Gulf-to-Atlantic Transport Through Tidal Channels in the Florida Keys. Bulletin of Marine Science, 54(3): 602-609.

Wang, J. D. and C. Monjo. 1995. A Study to Define Model and Data Needs for Florida Bay. Applied Marine Physics, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

Wang, J.D.; J. van de Kreeke; N.Krishnan and D. Smith. 1994. Bulletin of Marine Science, 54(3): 579-601.

Ecosystems Element

There are three significant habitat types in the Florida Keys: marine, uplands and wetlands. Each of these ecosystems are discussed in more detail in the following paragraphs. For each ecosystem in the Florida Keys, the studies and work within this element will include mapping; identification of indicator species, keystone species, and species of concern; identification of indicators of sustainability; development of scientifically derived requirements, responses, limiting factors and tolerance limits, where possible; and historical change analysis. This data will be integrated into the CCAM for determining the existing condition of the ecosystems and for simulating the effect of land development activities and effective human population on the ecosystems in each of the future scenarios. Using this data, CCAM will provide maps depicting future trends and areas requiring restoration.

Marine Environment

Critical components of the Key's marine ecosystem are the coral reef, seagrasses, and fauna targeted by commercial and recreational fisheries. Coral reefs are well known for their beauty and complex diversity of life. Reef communities are in some ways similar to forest communities on land, in that the dominant organisms provide other members of the community with food and shelter. Shelter, however, is the primary contribution of coral reefs. The massive and intricate frameworks constructed by reef building organisms provide an almost infinite array of habitats for plants and animals, leading to greater biologic activity and diversity than in most other marine environments (Myers et al. 1992). Seagrasses, on the other hand, serve as a nursery for marine life, providing food and protection from predators.

Land development activities and infrastructure can adversely impact the marine environment through nutrification, pollution, and sedimentation, primarily through wastewater and stormwater inputs into the nearshore waters. Nutrient rich and sediment laden water from external sources, such as the Gulf of Mexico or Florida Bay, may also impact the nearshore marine environment of the Florida Keys.

Direct human contact with marine flora and fauna from divers, anchoring, boat groundings, propeller dredging of seagrasses and harvest of specific species, have risen with increased permanent and seasonal human population. Unfortunately, voluntary use of mooring buoys and poorly understood channel marking systems are the only systems in place to prevent boating impacts.

Upland Habitats

Land development activities and infrastructure can fragment significant upland habitats, some of which are needed by endangered species for survival, the Key Deer for example. There is an established link between habitat protection and endangered species protection. Land development activities in the Florida Keys will continue to eliminate or fragment tropical hardwood hammocks and pine rockland habitats.

Wetlands

Wetlands include mangroves, freshwater wetlands, saltmarshes, and buttonwood wetlands. Wetlands in the Florida Keys have been mapped by EPA and Monroe County's Advanced Identification of wetlands program (ADID). Saltwater wetlands are important marine life nurseries in the Florida Keys. Wetlands are critical foraging habitat for numerous migratory and wading birds. In addition, wetlands provide an important buffer zone between developed uplands and the marine ecosystem by providing shoreline stabilization, flood control and water purification. Unique problems associated with the freshwater wetlands in the Lower Keys include contamination, draw down, saltwater intrusion of the watering holes for the endangered Key deer and the subsequent mortality of upland plants, such as slash pines.

Task 1. Literature Review. All available literature, information, data, GIS maps, research and published scientific literature regarding ecosystems within the Florida Keys will be reviewed, compiled, evaluated and documented. GIS coverages for the Florida Keys are available through FMRI and FGIB. The website for available FMRI GIS coverages is 'www.fmri.usf.edu/sori'. The website for the Florida data directory (FGIB) is 'sun6.dms.state.fl.us/als/public_html'. Additional research, data collection and GIS mapping will be conducted if required. There are numerous data available through the FKNMS, Florida Natural Areas Inventory (FNAI), FMRI, USGS and other researchers included in the resources section of this element.

Task 2. Delineate and Map Marine, Upland, Wetland Ecosystems and Transition Zones. The marine, upland and wetland ecosystems and transition areas will be mapped based upon existing delineations previously performed by FNAI, FMRI and Monroe County. Available GIS mapping and data from FKNMS, FNAI, FMRI, USGS, Monroe County and any other resources will be utilized to map the ecosystems and transition zones of the Florida Keys. Any identified gaps in the ecosystems delineation and mapping will be identified and GIS maps will be prepared.

Task 3. Identify Ecosystem Indicators of Sustainability for Each Ecosystem. A series of facilitated workshops will be held which will include members of the peer review group that reviewed the scope of work in March 1998; other natural resource experts; and local, state and federal agency representatives, as appropriate. It is anticipated that one to two workshops will be required:

Workshop Number 1. The first workshop will be held approximately one month following identification of indicator species, keystone species and species of

concern (see Species of Concern Element, Task 4). The goal of this workshop will be to identify natural resource indicators for each ecosystem within the Florida Keys ecosystems. The needs of identified indicator species, keystone species and species of concern will be included in the indicators. If the goal cannot be achieved at this workshop, direction for additional research will be obtained in preparation for workshop 2.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to present and discuss the proposed natural resource indicators, based upon results of the additional research directed by workshop 1.

Task 4. Develop Scientifically Derived Requirements, Responses, and Limiting Factors for all Ecosystem Indicators, Identifying and Quantifying Tolerance Limits, Where Possible. This study task will also require facilitated workshops, which are described in Section 3, Study Elements, Task 2. The requirements, responses, limiting factors and tolerance limits for all ecosystem indicators will be integrated into the CCAM for determining the existing condition of the Florida Keys and for simulating the effect of land development activities and human infrastructure on the ecosystems in each of the future scenarios.

Task 5. Habitat Change Analysis. A habitat change analysis will provide insight into habitat changes over time and their correlation to land development activities and effective population changes over time. In addition, it will assist in the prediction of habitat changes in the future scenarios. This analysis will use aerial photography for detecting change.

For habitat change analysis in the marine ecosystem, the FKNMS has identified five zones within the sanctuary for assessing natural resource and habitat changes: wildlife management areas, ecological reserves, sanctuary preservation areas, existing management areas, and special use areas. These zones, which encompass approximately 300 square miles, will be the focus of detecting changes. The changes within these zones must consider the management principles mandated by the FKNMS and the effect that these principles may have on the change analyses. Similar analyses by the FKNMS will be incorporated when available. Any marine areas in the Florida Keys that are not included in one of the five FKNMS zones will extrapolate the habitat change analysis from one of the five zones that is most similar and suitable.

For habitat change analyses in the upland and wetland ecosystems, GIS mapping and databases of the Florida Game and Fresh Water Fish Commission (FGFWFC) FKNMS, FNAI, USGS, Monroe County and other sources will be examined for existing habitat change analyses. Any areas not included in an existing habitat change analysis will extrapolate the analysis from an area that is similar and suitable.

Task 5.a. Identify Baseline Conditions. The oldest, suitable existing aerial photography will be utilized for identification of baseline conditions. One source is the color aerial photography of the Florida Keys flown by NOAA from December 1991 through April 1992. It is recognized that this photography does not provide a very long historical record for comparison, however, it may be the only suitable aerial photography for this analysis. Another potential source of historical aerial photography to be investigated is Pan American Surveys in Miami, Florida.

Task 5.b. Current Conditions. Multi-spectral digital aerial images of current conditions will be acquired and the habitats will be identified and delineated. For those areas located in the marine environment, SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) hydrographic survey data may be coupled with the multi-spectral images to produce accurate digital bathymetry. The SHOALS data will be acquired only if cost effective.

Task 5.c. Habitat Change Analysis. An analysis and comparison of the historical to current aerial photography will be made. Habitat changes, by type, will be documented, summarized in tables and mapped in GIS.

Task 5.d. Future Trends. Using this habitat change analysis and the change in land development activities and effective population that occurred during the habitat change analysis period, the relationship of habitat changes to land development activities and effective population changes in the Florida Keys will be developed. The regulatory changes that have occurred during the analysis period will be included in an effort to identify habitat changes driven by the regulatory changes. This information will be utilized to assist in determination of the relationship between each study element and land development activities and effective population changes for use in the CCAM for simulating the future scenarios.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, research, published scientific literature and GIS mapping of the ecosystems in the Florida Keys, not just the references and sources listed here.

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Chiappone, M. 1996. Site Characterization for the Florida Keys National Marine Sanctuary and Environs. Volumes 1 - 10. Publication of the Nature Conservancy. Vol. 1 Geology and Paleontology. Vol. 2 Oceanography and Shallow-water. Vol. 3 Historical Overview of Development and Natural History. Vol. 4 Marine Benthic Communities. Vol. 5 Invertebrate Infauna and Epifauna. Vol. 6 Fishes and Fisheries. Vol. 7 Nekton, Plankton, and Oceanic Influences. Vol. 8 Functional Ecology and Ecosystem Trophodynamics. Vol. 9 Controversies and Conservation Issues. Vol. 10 Bibliography of the Florida Keys and Environs.

Conservation and Recreation Lands Annual Reports.

Environmental Protection Agency, Monroe County Field Office.

FDEP. 1995-96. GIS Annual Report, lists GIS activities in the DEP. It documents and updates studies in which GIS technology has been integrated for ecosystem protection and management.

FDEP. 1995. A Plan for Forest Conservation in the Florida Keys.

FGFWFC GIS

Florida. December 1991. Aerial infrared photography with land coverage was flown for the state of Florida, including the Florida Keys. Topographic habitat polygon data are classified to a minimum of one half acre polygon size.

Florida GIS data directory (FGIB)=sun6.dms.state.fl.us/als/public_html.

Florida Key Deer Population Viability Assessment, 1990.

Florida Keys Environmental Restoration Trust Fund (FKERTF), as a source of past and potential restoration and enhancement projects in Keys, C. Kruer, Manager.

FKERTF. 1995. Invasive Exotics Mapping Project mapped all invasive exotics on Big Pine Key and No Name Key and other lands of National Key Deer Refuge in Lower Keys in aerial photo map atlas at a scale of 1" = 200'. Maps available from Kruer.

FKERTF is completing a similar exotics mapping project on all of North Key Largo in conjunction with Crocodile Lakes NWR.

Florida Keys Invasive Exotics Task Force has mapped all invasive exotics in the Keys at a scale of 1" = 1100', field data is presently being digitized to create a map atlas with accompanying assessment (see Kruer).

FKNMS Final Management Plan/Environmental Impact Statement.

FKNMS. First Biennial Report to Congress of the FKNMS Water Quality Protection Program.

FKNMS. December 1991 through April 1992. Natural color aerial photography of south Florida including Florida Bay, Biscayne Bay and the Florida Keys was flown by NOAA. The photography was flown at a scale of 1:48,000. The purpose of the work was to develop benthic habitat maps of the Florida Keys National Marine Sanctuary.

FMRI. FKNMS Benthic Communities Mapping (by Kruer and Zieman for FMRI and NOAA), GIS map atlas to be published by FMRI.

FMRI GIS available coverages=www.fmri.usf.edu/sori.

FMRI and Kruer. 1995. Land Use/Land Cover GIS Habitat Maps.

FNAI Habitat Maps.

Kruer, C. 1994. Mapping Assessment of Vessel Damage to Shallow Seagrasses in the Florida Keys. Final Report to DEP and University South Florida Institute of Oceanography. Contract No. 4710-123L3.

Kruer for EPA. Advanced Identification of Wetlands GIS mapping project for Monroe County.

Kruer for FNAI. 1993. An Assessment of Florida's Remaining Coastal Upland Natural Communities: Florida Keys, Monroe County.

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Myers, R.L., J. Ewel and M.H. Carr. 1992. *Ecosystems of Florida*. University Presses of Florida: Gainesville, Florida.

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National Audubon Research Center. Strong and Bancroft. Publications of Historical Changes in Upper Keys.

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USFWS. 1992. Management Agreement for Submerged Lands Within Boundaries of the Key West and Great White Heron National Wildlife Refuges.

USFWS. 1997. Multi-Species Recovery Plan.

Species of Concern Element

The classification of species as state and federally endangered species often result from diminished habitat or a species specific impact. The Florida Keys has a variety of endangered species endemic to a restricted range, such as the Key deer, American crocodile, silver rice rat, Key Largo cotton mouse, Key Largo wood rat, Lower Keys marsh rabbit, Key mud turtle, Stock Island tree snail, Shaus' swallow tail butterfly, piping plover, white-crowned pigeon, colonial nesting birds, shorebirds and several sea turtle species. Habitat protection that encompass numerous other animal and plant species offers a reasonable approach to species protection. Habitat conservation gaps and conservation easements need to be included in acquisition and protection strategies. Habitat encroachment, cumulative effects, and secondary effects such as increased introduction of exotic species near developments should be included in this portion of the study.

The studies and work within this element will use available data to identify and map threatened and endangered species and species of special concern; and identify indicator species, keystone species and other species of concern, including scientifically derived development of their requirements, responses, and limiting factors, identifying and quantifying tolerance limits, where possible. This data will be integrated into the CCAM for determining the existing condition of the indicator species, keystone species, and other species of concern; and for simulating the effect of land development activities, human infrastructure and effective population on those species in each of the future scenarios. Using this data, the CCAM will provide maps depicting future trends such as the impact of land development activities and effective human population change on the indicator species, keystone species, and other species of concern, as well as areas requiring restoration.

In addition, the optimum physical and chemical factors making up species' environment will be defined in general terms. This optimum environment is to be composed of, among other factors, the quantity, quality, composition, and juxtaposition of required habitats. A biological community description (dominant vegetation types) for the indicator species, keystone species and other species of concern, as well as threatened and endangered species and species of critical concern will be included. It is acknowledged that many of the indicator species, keystone species and other species of concern are the endangered and threatened species and species of critical concern since they are good indicators of general environmental trends. The structure of community types will be described including limiting factors affecting growth and abundance or distribution of species populations.

The FGFWFC, FNAI and U.S. Fish and Wildlife Service (USFWS) have extensive information available on endangered species. For example, the USFWS Multi-species Recovery Plan contains all the latest natural history information on the 68 endangered or threatened species in South Florida and the FGFWFC has published "Closing the Gaps in Florida's Wildlife Habitat Conservation System". Several habitat-based GIS applications

are available through the FDEP. The carrying capacity model for endangered species will include some refinement of existing GIS databases and computerization of FDEP's conservation easement database.

Task 1. Literature Review. All available literature, information, data, GIS maps, research, and published scientific literature regarding threatened and endangered species and species of critical concern within the Florida Keys will be reviewed, compiled, evaluated and documented. Additional research, data collection and GIS mapping will be conducted where required.

Task 2. Identification of Species. Using existing lists from Monroe County; FNAI; FGFWFC; Florida Department of Agriculture and Consumer Service, Division of Plant Industry; and USFWS, threatened and endangered species and species of critical concern will be identified including populations of amphibians, arthropods, birds, fish, mammals, mollusks, plants and reptiles present in the Florida Keys.

Task 3. GIS Mapping of Occurrence of and Habitat Locations of Threatened and Endangered Species and Species of Critical Concern within the Florida Keys. The biological community and habitat attributes of threatened and endangered species and species of critical concern within the Florida Keys will be mapped in GIS.

Task 4. Identification of Indicator Species, Keystone Species and Other Species of Concern. Due to the multitude of species living in the Florida Keys ecosystem, indicator species, keystone species, and other species of concern must be identified so that the CCAM is not overwhelmed. Using the data from tasks 1, 2 and 3, the indicator species, keystone species and other species of concern will be identified. The identified species will be subject to the approval of the PMT.

Task 5. Develop Scientifically Derived Requirements, Responses, and Limiting Factors, Identifying and Quantifying Tolerance Limits, Where Possible, for the Indicator Species, Keystone Species and Other Species of Concern. See Section 3, Study Elements, Task 2. The requirements, responses, limiting factors and tolerance limits for the indicator species, keystone species and other species of concern will be integrated into the CCAM for determining their existing condition within the Florida Keys and for simulating the effect of land development activities and human infrastructure on them in each of the future scenarios.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, GIS maps, research, and published scientific literature regarding threatened and endangered species and species of critical concern within the Florida Keys, not just the references and sources listed here.

Chiappone, M. 1996. Site Characterization for the FKNMS and Environs. Volumes 1 - 10. Publication of the Nature Conservancy.

FDEP GIS Book. *1995-96 Annual Report*. It lists GIS activities in the DEP and documents and updates studies in which GIS technology has been integrated for ecosystem protection and management.

FGFWFC. 1994. Closing the Gaps in Florida's Wildlife Habitat Conservation System.

FGFWFC Databases.

Florida Keys Invasive Exotics Task Force GIS.

FKNMS Final Management Plan Environmental Impact Statement.

FNAI Databases.

Folk, Klimstra, and Kruer. 1991. Habitat Evaluation: National Key Deer Range. Prepared for FGFWFC Non-game Program.

Nature Conservancy Florida Keys Initiative. Science Brief.

South Florida Region Planning Council, Hollywood, Florida. September 1995. Florida's Marine Resource Information System, Final Report. The report is a publication of the Florida Department of Community Affairs, Coastal Management Program, funded by a grant from NOAA.

USFWS Biological Opinion for FEMA.

USFWS GIS.

USFWS Multi-Species Recovery Plan.

Human Infrastructure Category

Fundamental to any development initiative is the need for a certain level of supporting services and facilities. Florida state law requires local governments to ensure established levels of services and facilities which support their approved comprehensive plan. Current land use policies in turn dictate future demands. Human Infrastructure as a category shall emphasize those elements integral to the environmental evaluation of the CCAM and hurricane evacuation since it is a paramount consideration in the Florida Keys due to limited evacuation routes. The integral elements will be population forecast; stormwater; wastewater; transportation; marinas, heavily traveled channels, ports; and hurricane evacuation. Other elements needed to determine adequate supporting services and facilities will be rolled into "Other Infrastructure Services". Other infrastructure services will include police and law enforcement; schools; hospitals/health delivery; fire/emergency services; and recreation. The primary focus of other infrastructure services

investigations will be to identify the cost for additional infrastructure construction or retrofit in the CCAM simulation of the future scenarios. All applicable information from the Monroe County Comprehensive Plan will be incorporated into the development of this element to avoid any duplication of effort.

Population Forecast Element

Task 1. Permanent and Seasonal Population Analysis.

Task 1.a. Calculate current effective population of the Florida Keys. If various sources (i.e., agencies, studies, etc.) provide population data that is in disagreement, an effort will be made to reconcile conflicting data. This can be accomplished by (1) contacting responsible sources and requesting data updates and/or acceptable error ranges and (2) utilizing census information, researching property appraiser's listings, etc. Key subparts of the effective population shall be analyzed and forecast, including, but not be limited to, visitors (tourists), the elderly, and children.

Task 1.b. Forecast of Future Effective Level of Population. Estimates shall extend from past trends, and, at the same time, incorporate such factors as anticipated commercial/industrial growth, economic class shifts, developable land available, local birth and death rates, and government activities. The local census bureau, planning office, chamber(s) of commerce, office(s) of tourism, local utility company(ies), and movers are some sources of information that will be consulted in making projections.

Short-term (2010 projection) and long-term estimates (50-yr) will be provided. Effective level of population, economic land use, and other associated planning studies will be referenced. Population forecasts should be capable of showing anticipated patterns of growth and development in the Keys (i.e. where population growth is expected to occur), and show estimates according to permanent and seasonal residents, and tourist populations. Resultant population projections will be used to estimate demands on human infrastructure elements identified in this scope of work.

Resource:

University of Florida, Bureau of Economic and Business Research.

Wastewater Element

This element will utilize information from the Monroe County Sanitary Wastewater Master Plan. Therefore, coordination with Monroe County is required. The future wastewater requirements, based on future land development activities and effective population assumptions, will be utilized in the CCAM simulation of the future scenarios. Within this study, wastewater is also addressed under the Water Quality Element of the Natural Resources Category, since acceptable water quality is a paramount environmental consideration for the Florida Keys ecosystem.

Task 1. Estimate Current and Projected Wastewater Flows. Current capacity in gallons per day (gpd) for wastewater treatment facilities will be estimated. Future wastewater flows in gpd will be projected based upon effective population forecasts from the Population Forecast Element. The future estimates will consider the needs of the CCAM for simulating the future scenarios.

Task 2. Identify Future Wastewater Treatment Requirements. A comparison of current and projected wastewater treatment capacities in gpd will be made. Shortfalls will be identified.

Task 3. Evaluate Alternatives to Meet Projected Wastewater Treatment Requirements.

Task 3.a. Compare Centralized Wastewater Collection and Treatment Alternatives with OSDS.

Task 3.b. Evaluate Existing Wastewater Collection Systems. Existing waterwater collection systems will be evaluated to determine the degree to which they could be utilized in centralized wastewater collection and treatment alternatives. This effort will provide an estimate of the number or percentage of OSDS that could be replaced by the implementation of centralized wastewater collection and treatment facilities.

Task 3.c. Evaluate Potential Wastewater Collection and Treatment Alternatives. A minimum of three of the most favorable alternatives (or combinations of alternatives) will address the following:

(1) The maximum reasonable utilization of existing wastewater collection facilities;

(2) The use of centralized, clustered, and decentralized approaches; and

(3) The inclusion of "hot spots" identified in the Water Quality Element.

The cost for each of the favorable alternatives or combination of alternatives will be provided for integration into the CCAM for simulating the future scenarios.

Stormwater Element

This element will utilize information from the Monroe County Stormwater Master Plan. Therefore, coordination with Monroe County is required. Future stormwater treatment requirements, based on future effective population assumptions, will be utilized in the CCAM simulation of the future scenarios. Within this study, stormwater is also

addressed within the Water Quality Element of the Natural Resources Category, since acceptable water quality is a paramount environmental consideration for the Florida Keys ecosystem.

Task 1. Quantify Significant Stormwater Flows into "Hot Spot" Areas. Stormwater runoff flows into "hot spot" areas will be calculated by the use of a method that relates rainfall to runoff. One, or a combination, of the following methods may be used:

(1) Rational Method. Use of this method shall require proper selection of runoff and retardance coefficients. This method is best suited for the urban areas of the Florida Keys where a high percentage of imperviousness is common. (References: "Design and Construction of Sanitary and Storm Sewers," Manual of Engineering Practice No. 37 {New York: American Society of Civil Engineers, 1960}; C.F. Izzard, "Hydraulics of Runoff from Developed Surfaces, Proc. Highway Res. Bd. 26 (1946): 129-150).

(2) Simulation Models. Such simulation models as the EPA's Stormwater Management Model may be used as a basis for the development of site-specific model(s) designed to estimate significant stormwater runoff into "hot spot" areas.

Task 2. Estimate Current and Projected Stormwater Flows. Current stormwater flows will be estimated. Future stormwater flows will be projected based upon land development activities and effective population forecasts from the Population Forecast Element. The future estimates will consider the needs of the CCAM for simulating the future scenarios.

Task 3. Identify Future Stormwater Treatment Requirements. A comparison of current and projected stormwater treatment capacities will be made. Shortfalls will be identified.

Task 4. Evaluate Alternatives to Meet Projected Stormwater Treatment Requirements. The following programs, some of which are listed in the WQPP, will be analyzed and evaluated for potential to significantly contribute to the reduction of pollution from stormwater runoff.

(1) Street Sweeping,

(2) Ordinances for controlling fertilizer application on public and private landscaping,

(3) Collection locations and a public education program for the proper use and disposal of household fertilizers, pesticides, motor oil, and other hazardous household chemicals,

(4) Retention/detention treatment ponds (including cost for integration into the CCAM for simulating the future scenarios), and

(5) Litter control programs and public education programs.

Evaluations are to include, but not be limited to, defensibly calculated estimates of mass removals of key pollutants (e.g. Total Phosphorus, Total Nitrogen, Total Suspended Matter, Metals, Hydrocarbons, etc.) that will occur as a result of each program.

Transportation Element

U.S. Highway 1 is the main road linking the individual islands and communities to each other and to the mainland. The primary purpose of this element will be to ensure that the road network is adequate to provide hurricane evacuation for the effective population in each of the future scenarios. Traffic volumes under the future scenarios and population forecast will be estimated, and compared to the transportation network capacities. Shortfalls in capacity will be identified. Accepted methodology utilized by Florida Department of Transportation (FDOT) will be applied.

Task 1. Estimate Current Traffic Volumes on Key's Primary and Secondary Roads.

Task 2. Develop Relationships Between Traffic Volumes and Population and Demographic Variables (number of trips, origin-destination, permanent, seasonal residents, tourists, etc.).

Task 3. Determine Capacity and Level of Service of Current Transportation Network.

Task 4. Project Future Traffic Volumes Based on Population Forecast and Scenario Assumptions.

Task 5. Identify Shortfalls in Capacity and Level of Service of Transportation Network.

Relevant Data: (This list of data items should be related to the traffic projection and analysis tasks so that only the most useful data is collected.)

-Traffic counts by the FDOT
-Traffic delay studies by Monroe County
-Traffic circulation patterns
-Traffic speed data
-Accidents involving wildlife
-Accident data by the Florida Highway Patrol, Monroe County Sheriff and FDOT

-Potential build out of each island (Development and population projections from all scenarios will be needed to predict the alternative future traffic volumes.)
-Potential build out and land uses in South Dade County as they pertain to the Hurricane evacuation route exiting the Florida Keys
-Historic number of permits for residential units by island (as defined in the Monroe County Rate of Growth Ordinance)
-Census data for household size, number of automobiles per household
-Hotel occupancy rates as may be maintained by the Monroe County Tourist Development Council and/or local Chambers of Commerce
-Monroe County Comprehensive Plan, Technical Background Data including the origin-destination data

Factors:

-Trip generation rates of different land uses.
-Locations of different land uses.
-Automobiles per household.
-Alternative means of travel such as but not limited to transit, taxi, bicycle, and walking.

Relationships:

Reductions in the level of service standards will impact other elements such as response times by Emergency Services. The capacity and condition of roads will also affect the ability to evacuate the Keys in the event of an approaching hurricane. However, such an evacuation shall also be dependent on the road network and shelters out of the Keys.

Consider alternative systems that look beyond present practices and are environmentally friendly, such as: local and express buses; inter-county buses; multi-use trails for bicycles and walkers, etc.

Marinas, Heavily Traveled Channels, Ports Element

The residents and tourists of the Florida Keys use a variety of facilities in support of water navigation and recreational boating. Three major supporting facilities are marinas, channels, and ports. Vessels and their operation, maintenance and associated infrastructure have impacts on water quality and the coastal and marine environment. The information provided in this element will be utilized within the FKCCS and the CCAM to provide data for the impacts of marinas, channels, ports and boats on the water quality and marine environment of the Florida Keys, both existing impacts and future impacts due to increased effective population and demand.

Task 1. Identify all Marinas, Heavily Traveled Channels and Ports. All marinas, heavily traveled channels and ports (public and private) in the study area will be identified

and will include wet slips, dry racks, boat ramps, parking lot capacity, docks, boat repair facilities, and pump out facilities.

Task 2. Estimate the Current Annual Demand for Marinas, Heavily Traveled Channels and Ports. Effective population and standard participation rates will be used to estimate the total number of visits to marina and port facilities annually. Live-aboards will be included.

Task 3. Estimate the Current Annual Supply Capacity. Using standard outdoor recreation and/or navigation capacity tables where possible, the annual supply capacity will be estimated.

Task 4. Estimate the Projected Future Demand. The project future demand for marina, heavily traveled channels and port facilities will be estimated based on projected effective population increases in the future scenarios.

Relevant Data:

FDEP GIS Book. *1995-96 Annual Report.*

University of Miami, Rosentiel School of Marine and Atmospheric Science, Division of Marine Affairs and Policy. 1995. *Urban Growth and Sustainable Habitats, Case Studies of Policy Conflicts in South Florida's Coastal Environment*. "To Jet Ski or Not to Jet Ski: Personal Watercraft Conflicts in the Lower Keys." Pages 133-154.

Simmons, Alyson. Community Outreach Coordinator, FKNMS. *Boater Education in the FKNMS.*

USACE, Jacksonville District, Federal projects in Monroe County:

Key West Harbor, Key West Bight, Garriod Bight
Intracoastal Waterway, Miami to Key West
Largo Sound Channel
Smathers Beach, Key West, Florida Shore Protection Project.

Hurricane Evacuation Element

Current hurricane evacuation problems and needs in the Florida Keys, Monroe County, Florida will be evaluated. The overall objective of this is to provide emergency management officials with comprehensive and updated information on the major items affecting hurricane evacuation planning and decision-making.

Task 1. Existing Data Collection. Existing data will be collected to identify baseline conditions and, where appropriate, converted to GIS. A detailed description of each geographic data layer (coverage) is summarized in Appendix A of the report:

"Florida's Marine Resource Information System Final Report," South Florida Regional Planning Council, September 1995. Database coverages contained in the FMRIS that are relevant to the Hurricane Evacuation Element of this study include: Hospitals, Keys Treatment Plants, Major Roads, Schools and other shelter facilities, etc.

Task 1.a. Topographic Data. The most current existing topographic data will be included in the study database. The FDOT has recently flown aerial photography suitable for updating base mapping for new inundation maps, more accurate shelter evaluations and approaching roadways.

Task 1.b. Flood Data. Flood information and data from the most recent maps and atlases developed from the results of the Sea, Lake and Overland Surge from Hurricanes (SLOSH) Modeling provided by the National Hurricane Center (NHC) and the most recent FIRM's from FEMA Flood Insurance Studies (FIS) will be included in the study database. A new SLOSH Model for the Florida Bay Basin is scheduled to start in Oct/Nov 1998 with expected completion before June 1999.

Task 1.c. Hazardous Sites. Hazardous sites such as propane storage facilities, natural gas pipeline terminals, fuel storage facilities, tank farms, etc., shall be inventoried with a brief discussion of the facility. These facilities will be located by their state plane coordinates or longitude and latitude so they can be displayed on a map showing their proximity to shelters and critical facilities. The County shall play a major role in developing this data.

Task 1.d. GIS Mapping. Each major land feature, evacuation routes, roadway profiles, infrastructure, shorelines, spot-elevations and contours will be placed in separate coverages.

Indicators:

Indicators such as resident and tourist populations, structures, buildings, road infrastructure, waves, storm surge, tides, topographic and bathymetric elevations are relevant to the hurricane evacuation study element. Factors such as number of permits issued for new construction and reconstruction are directly related to total population of the Florida Keys and affect the ability of people to evacuate the Florida Keys as a storm approaches.

Limits & Scope:

Some information, such as wave, surge and wind data, may be needed from areas outside the study boundary limits. The hurricane evacuation potential for Monroe County is related to the hurricane evacuation capabilities in the adjacent counties to the north. Hurricane evacuation information on Dade County, and other counties, shall be included as necessary and factors that affect the evacuation of the Florida Keys shall be defined.

Relevant Data:

Base maps depicting other factors and elements of importance to this hurricane evacuation element will be developed as a part of the FKCCS. Critical parameters are the location of transportation routes, populations, buildings, topography and storm characteristics. The latest approved Monroe County Land Use Plan shall be consulted for proposed land development activities and population densities at build out. The location of all mobile homes, trailers, and substandard housing will be delineated on maps.

Resources:

FDEP GIS Book. *1995-96 Annual Report.*

FEMA. March 3, 1997. *Flood Insurance Study, Monroe County, Florida and Incorporated Areas.*

South Florida Regional Planning Council. September 1995. *Florida's Marine Resource Information System Final Report.*

Task 2. Hurricane Evacuation Analyses. Hurricane evacuation analyses will have the capacity to evaluate the problems and opportunities associated with a growing demand for hurricane evacuation capability from the Florida Keys as described in the following:

Task 2.a. Hazards Analysis. The basis for the hazards analyses will be the most recent maps and atlases developed from the results of the SLOSH Modeling provided by the NHC and the most recent FIRM's from FEMA's FIS's for the County and local communities (See Task 1.b. Flood Data). Hazards from inland wind effects shall be evaluated, since these are considered critical where sub-standard housing and mobile homes are located. The hazardous sites mapping from task 1.c. will be utilized here.

Task 2.b. Potential Hazards. The hazards analysis shall identify the potential tropical storm hazards to the County and shall include investigations of potential storm surge/tide, waves, high winds, roadway flooding by rainfall runoff and storm tide occurring prior to the arrival of and during tropical storms, and a history of tropical storms activity in the region. If necessary, the NHC, FEMA, DCA and Monroe County will serve on an oversight committee to review any modeling activity relating to tropical storms hazards.

Task 2.c. Tropical Storm Surge. A new SLOSH Model by the NHC is scheduled to begin in Oct/Nov 1998 and should be completed by June 1999.

Task 2.d. Evaluate Sea Level Datum. Compilation of existing gage data or other method will be used to determine the current Mean Sea Level as compared to the standard National Geodetic Vertical Datum established in 1929. Some data would indicate that sea level may have increased about 0.7 foot since 1929. Continuous NOAA, National Ocean Service tide gage records exist for Key West from 1913 to the present. These existing records will be used and a new tide gage is not required.

Task 2.e. Freshwater Flooding. FIRMs and past freshwater flooding experiences (e.g. repetitive flood areas) will be used to determine the approximate number of vulnerable dwelling units subject to evacuation outside the surge inundation area. The number of dwelling units is to be based on Monroe County GIS parcel maps, and building locations identified from aerial photography. All roadways subject to freshwater flooding

will be identified and placed in a GIS coverage. Mapping of fresh water flooded areas are shown on the FIRM for the County, which are available in digital format.

Task 2.f. Tropical Storm Inundation Atlases. Inundation mapping will be performed showing areas that will be flooded by storm surge. The storm inundation maps will be shown with wave heights added to the storm surge.

Task 2.g. Vulnerability Analysis. The vulnerability analysis will include a comprehensive evaluation and identification of the levels of vulnerability, primary evacuation zones, the population-at-risk, and tropical storm surge effects on institutional/medical facilities as well as dry storage facilities. All vulnerable properties will be put into the study database. Additional information will be provided showing those segments of U.S. 1 and Card Sound Road that will be overtopped initially under the various hurricane scenarios and storm tracks. This inundation information for each scenario will be shown on a plan overlay to the U.S. 1 and Card Sound Road area. This will be very useful for the deployment of emergency vehicles during the pre-landfall period.

Task 2.h. Population Data. Provide/update information, by evacuation zones, on special needs populations, the estimated number of people living in various dwelling unit types by seasonal occupancy rates, the estimated tourist population, the number of people to be evacuated, and the number of vehicles to be used in an evacuation effort. Population estimates should be based on the year 2000 estimates and should include 5-year population projections to 2050.

Task 2.i. Life Safety/Critical Facilities Surge Analysis. Work to be performed for this analysis will include inventories and determinations of storm surge susceptibility of medical facilities, nursing homes, detention centers, schools and other institutions that may require special consideration during evacuation. Also, a determination of storm surge vulnerability will be made for other critical facilities such as water supply lines, wastewater treatment plants and electrical generating/transfer facilities. Critical facilities will be located by state plane coordinates and longitude and latitude.

Task 2.j. Demographic/Socio-Economic Profile. A summary of the demographic and socio-economic profile of the County will be provided.

Task 2.k. Mobile Home/RV Parks. The name and location of all mobile home and recreational vehicle parks will be provided in tabular and GIS format. These units are particularly vulnerable to high winds and are always evacuated during any hurricane threat.

Task 2.l. Special Considerations. Identify any areas and population (see Social Environment Element) that require special consideration relative to preparedness, warning and evacuation such as handicapped, elderly and families with small children.

Task 2.m. Strategies. A discussion of evacuation and sheltering strategies for the County (e.g. phased evacuation, close routes at certain hours before landfall, refuge use notification timing) based on relevant transportation analysis will be provided.

Task 2.n. Behavioral Analysis. A behavioral analysis will be provided based on discussions with County Emergency Management Directors or upon an appropriate recent survey of area residents to investigate the likely evacuation responses under a variety of hurricane threat situations.

Task 2.o. Shelter Analysis. Shelter analysis data will be updated and stored in a standard database format to promote ease of updating and compatibility. The traditional analyses would address critical parameters of existing shelter evaluations, existing private shelter, projected shelter needs, and other potential shelter options such as refuge of last resort and/or vertical evacuation alternatives.

Task 2.p. Transportation Analysis. The transportation analysis will be a regional study including estimates of vehicle movements into and out of the region. The study will incorporate and build on previous studies and utilize professionally accepted transportation models or other appropriate computer analysis systems. General study methods and modeling procedures will be documented. The analysis will investigate various evacuation methodologies, timing strategies, shelter/refuge strategies, and traffic control measures in order to minimize clearance times. Sensitivity analyses will be conducted to evaluate the impacts of variations in population; mobilization response curves simulating a quick, medium, and slow response; increase and reduction in highway capacity; drawbridge operations; percent of vehicles pulling trailers; and seasonal and tourist population.

Resources:

FDEP GIS. *1995-96 Annual Report*.

Post, Buckley, Schuh & Jernigan, Inc. for USACE and FEMA. January 1993. *Hurricane Andrew Assessment - Florida, Review of Hurricane Evacuation Studies Utilization and Information Dissemination*.

South Florida Regional Planning Council. June 1987. *South Florida Hurricane Contingency Planning Study*.

USACE and Monroe County Civil Defense. February 1991. *Monroe County Hurricane Emergency Plan.* This report was based on vulnerability and shelter analysis that were completed in 1989 and utilized 1984 shelter data. The transportation analysis was completed in 1991 and utilized 1980 census data that was updated to 1988 values. Hurricane data available through 1987 was utilized. The SLOSH modeling utilized was completed in January 1990.

USACE, FEMA, NOAA, NHC, DCA. February 1991. *Lower Southeast Florida Hurricane Evacuation Study, Technical Assessment, Monroe County*.

USACE, FEMA, NOAA, NHC, Florida Division of Emergency Management. October 1989. *Lower Southeast Florida Hurricane Evacuation Study, Monroe County Appendix*. The following reports were included in the Appendix: "Behavioral Analysis, Lower Southeast Florida Hurricane Evacuation Study," University of South Florida; "Hazard Analysis Monroe County, A Storm Surge Atlas for the Florida Bay Area," Storm Surge Group, NHC, NOAA; "Transportation Analysis, Monroe County, Lower Southeast Florida Hurricane Evacuation Study, Technical Data Report," Post, Buckley, Schuh, & Jernigan, Inc.; "Vulnerability Analysis, Monroe County."

Other Infrastructure Services Element

This element will provide the cost of all other infrastructure services required for effective population changes in the CCAM simulation of future scenarios. Other infrastructure services will include water supply, police and law enforcement, schools, hospitals/health delivery, fire/emergency services, and recreation. Information from the Monroe County Comprehensive Plan and other readily available sources will be utilized to the maximum extent.

Task 1. Estimate Current Levels of Service. Current levels of service for each of the other infrastructure services will be estimated.

Task 2. Estimate Future Required Levels of Service. Projected future levels of service will be estimated based upon the effective population forecasts in the CCAM simulation of future scenarios.

Task 3. Identify Shortfalls in Levels of Service. Shortfalls in levels of service will be identified by comparing projected and current levels of service.

Task 4. Estimate Cost for Providing Required Future Levels of Service. Costs for all infrastructure services that indicate a shortfall in any of the future scenario simulations will be estimated. This information will be integrated into the CCAM.

Social Environment Category

As stated earlier, the objective of the FKCCS is to conduct a carrying capacity study in the Florida Keys such that land development activities and effective population changes are linked with environmental impact, infrastructure improvements and impacts on the social environment, including economic, sustainable tourism, quality of life and community character. This category is concerned with developing an understanding of those socioeconomic forces driving and being impacted by change in the Keys as well as how these forces effect community life. There is concern that standard sociological, anthropological and social impact assessment methods have not worked in the past and

innovative methods must be promoted and utilized, wherever possible, in this analysis. Therefore, not only will the standard methods be utilized, an effort will be made to seek, promote and utilize new, innovative methods for the socioeconomic analyses and assessments in this category.

Tasks are not exclusively sequential. Some can be done concurrently, and some iterations are expected, especially as input is derived from the public involvement program (see Public Involvement, Section 2).

Task 1. Literature Review. U.S. Bureau of the Census and local planning studies and reports will be used to the extent practicable. The literature search will include information, if available, about social attitudes towards other carrying capacity studies throughout the world. For example, where has the social environmental been ascertained and factored into carrying capacity studies. This information will be useful for developing techniques and approaches, as well as for previous lessons learned. Some new data collection may be required, especially concerning public preferences and attitudes associated with the public involvement program.

Task 2. Existing and Historical Socioeconomic Description. The existing and historical socioeconomic environment in the Keys will be described, including identification and description of the significant socioeconomic forces that have produced or are producing; or may be impacted by, environmental and social change in the Keys.

Task 2.a. Develop Profile of Socioeconomic Structures and Processes. A descriptive profile of socioeconomic structures and processes of the Florida Keys communities will be developed using standard and new, innovative sociological, anthropological, social impact, and regional development assessment methods (see Finsterbush et al. *Social Impact Assessment Methods*, 1983. Sage). The social profile should describe existing conditions and significant historical trends and, at a minimum, include the following factors, plus any additional elements that are identified through public involvement efforts (See Public Involvement, Section 2):

(1) Population composition (number, age, sex, migration patterns, distribution, ethnicity, race, education, live-aboards, income distribution, identification and distribution of traditional disadvantaged population groups); visitor demographic characteristics (numbers, distribution, seasonal patterns of visitation);

(2) Regional economy must be described and analyzed in detail, including income, employment patterns, occupation distribution (i.e. how do residents make a living—factory workers, restaurant workers, fishermen, etc.), identification of key economic sectors and type of economy (e.g. tourism, fishing, retirement living), commuting patterns, unemployment, underemployment and local fiscal conditions;

(3) Community character/quality of life pertains to valued amenities and qualities that combine to make the Keys a special place to live. The amenities and

qualities that constitute community character/quality of life elements can only be discerned through public input; however, it is likely that the following elements will be part of such a list: lifestyles, perceptions of safety, perceptions of neighborliness, pride in being part of the Keys community, awareness/acceptance of community norms, pace of life, relation to/valuation of natural environment, aesthetics i.e. visual character along U.S. Highway 1, recreation, employment and noise levels;

(4) Recreation and entertainment;

(5) Tourism; and

(6) Zoning, planning and land use.

Task 2.b. Develop Socioeconomic Relationships. The significant relationships among elements in the socioeconomic profile, human infrastructure and natural resources categories will be identified in an effort to describe potential socioeconomic changes that may occur and the impacts of such change. The socioeconomic elements that are contributing to change in the Florida Keys and that could potentially impact carrying capacity levels will be identified. Similarly, the socioeconomic elements that may be impacted by human infrastructure or natural resources, or from constraints imposed by carrying capacity levels will be identified. For example, effective population impacts human infrastructure and natural resources carrying capacities. Tourism is likely to be impacted by natural resources, such as water quality. Understanding of these key relationships will be utilized for assessing the socioeconomic environment in the future scenarios.

Task 3. Develop, Describe and Analyze the Socioeconomic Environment Under Future Scenarios. For each study scenario, projections of socioeconomic indicators will be included in the assumptions in an effort to represent the Keys socioeconomic environment under that scenario. Socioeconomic changes and their impact on the socioeconomic environment of the Florida Keys will be identified. The analysis will describe changes from existing conditions and significant changes in past trends. Similarities and differences between alternative scenarios will also be highlighted.

Task 4. Identify Socioeconomic Impacts that are Potentially Unacceptable to Segments of the Keys Community or to Other Appropriate Populations. The significant impacts associated with socioeconomic change are likely to conflict with views, preferences, or attitudes of the Keys community, with major segments of that community, or with other appropriate populations, such as tourists or non-resident permitted landowners. Traditionally disadvantaged groups will be identified and their socioeconomic preferences will be incorporated in this impact assessment. This will ensure that not only the views and preferences of the most vocal advocates for or against the FKCCS are included, but also those groups that may not have the opportunity, knowledge or ability to be vocal about their views and preferences.

Standard and new, innovative sociological, anthropological, social impact assessment methods, as well as appropriate input from the public involvement program, will be evaluated to identify and describe potentially unacceptable impacts. The description will include the group or segment of the community or other population likely to find the impact unacceptable and the underlying reason for their sentiment.

Resources:

FDEP GIS Book. *1995-96 Annual Report.*

Florida Keys/Key West Report. 1996. *Economic Contribution of Recreating Visitors to the Florida Keys/Key West*.

Florida Keys/Key West Report. 1996. *Importance and Satisfaction Ratings By Recreating Visitors to the Florida Keys/Key West*.

Florida Keys/Key West Report. 1996. *Visitor Profiles Florida Keys/Key West*.

Note: The three preceding reports are available on the World Wide Web at:
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